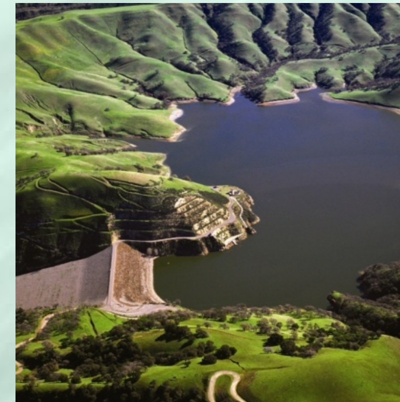

Planning for an Uncertain Future

Connecting Regional Resource Management Strategies to the California Water Plan

Rich Juricich
California Department of Water Resources
David Purkey
Stockholm Environment Institute
David Groves
RAND Corporation

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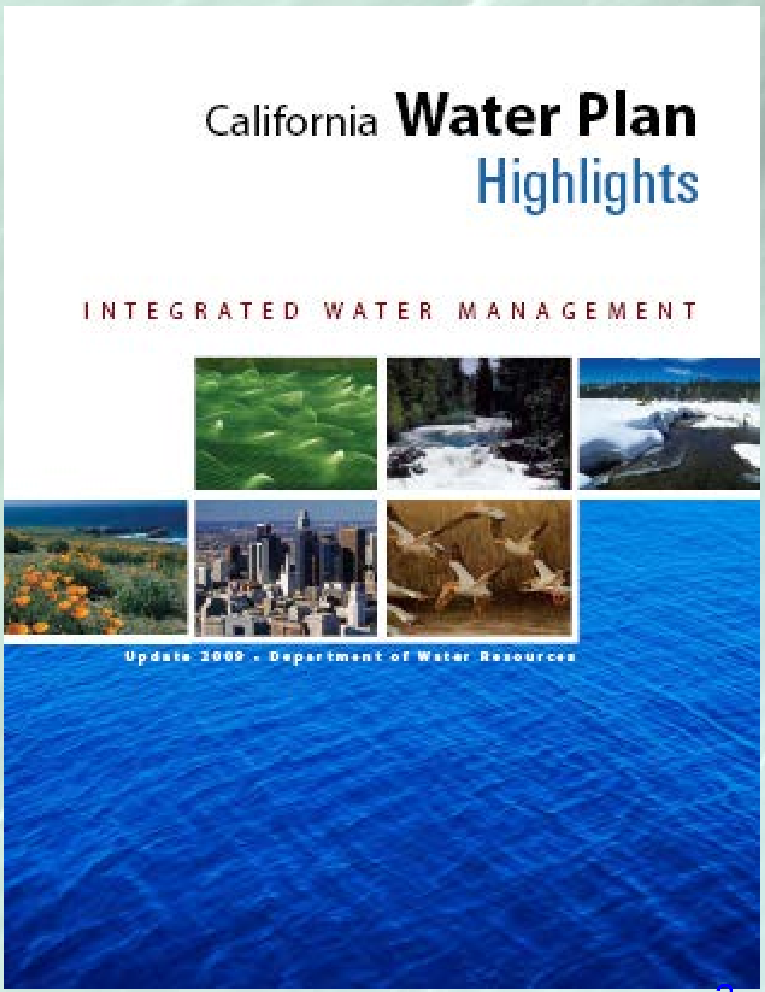
The California Water Plan Est. 1957

- First published in 1957
- Updated 9 times; last one in 2009
- DWR required by law (Water Code) to update the Water Plan every 5 years; next one in 2013
- Growing interest by Legislature and stakeholders
- Not a mandate & No appropriation



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California Water Plan

State's Blueprint for
Integrated Water Management & Sustainability

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Risk, Uncertainty, and Sustainability

Planning for an Uncertain Future

Seeking shared understanding of :

- The existing state (of water) in the regions
- A range of multiple, plausible future conditions
- What the options are to manage current and future conditions
- The options that seem to make the most sense to invest in, in different regions

Partnering with the California Water Plan

- Highlight priorities in your region
  - Resource management strategies
  - Management objectives
- Define success for your region
  - Important performance measures
- Identify interregional connections
  - Dependencies and partnerships

Benefits of Partnering with the California Water Plan

- Access to WEAP model
- Scientifically vetted scenario of future climate change
- Quantified information on Inter-regional connections (runoff, stream flow, groundwater)
- Extensive public outreach ar inclusion in Update 2013
- Coordination with Basin Stud and System Re-operation Study

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On the Agenda Today

- Learn about the tools and analysis the California Water Plan is using to evaluate risk and uncertainty
- Solicit your advice on describing resource management strategies in your region
- Solicit your advice on defining success for your region with respect to integrated regional water management

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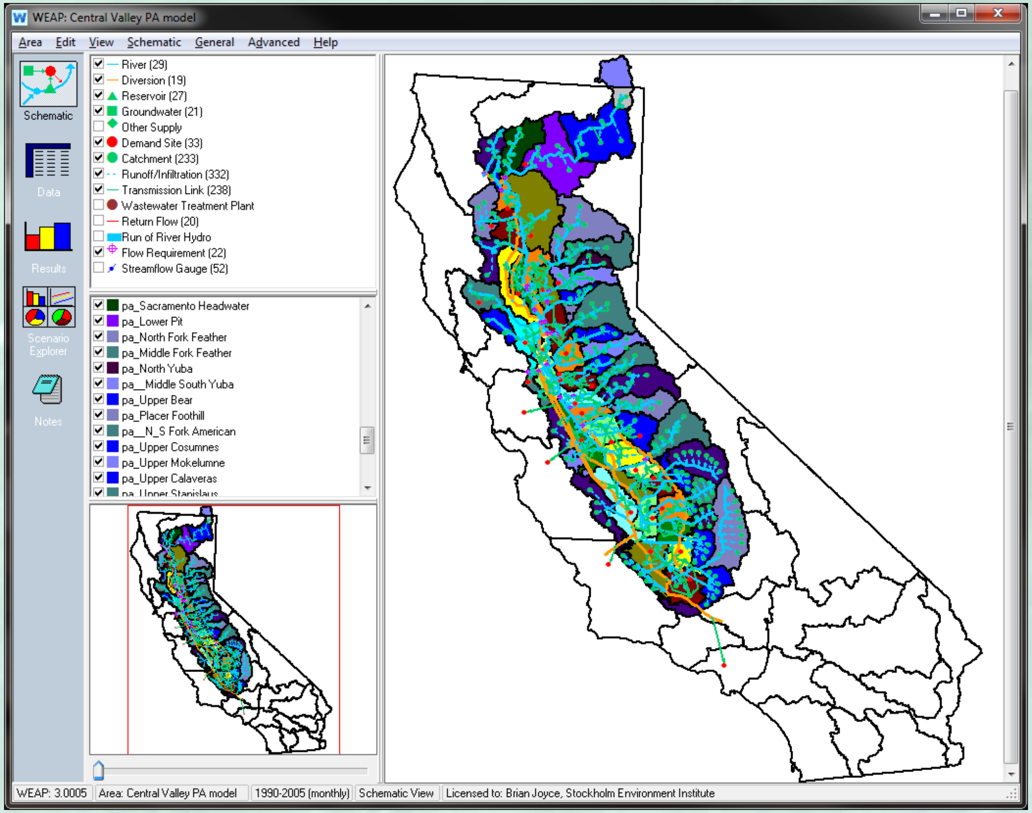
Key Terms

- **Performance measure**
- **Resource management strategy**
- **Response package**
- **Scenario**

Introduction to the Central Valley WEAP Model



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Planning Approach
Case Studies

CWP Planning Approach Designed for Long-term Decision-making

- *The future is uncertain*: no single prediction of the future is adequate for planning
- *There is no silver bullet*: there are many options and important tradeoffs among them
- *Analysis can only inform policy decisions:* Analysis supports deliberation over tradeoffs

Planning Approach Has Been Applied at the Regional and Local Scales in California

- *Inland Empire Utilities Agency*: Preparing for an Uncertain Future (NSF: 2006-2008)
- *Metropolitan Water District of Southern California*: Vulnerability Assessment of its 2010 Integrated Resources Plan (MWD: 2011-present)

Planning Approach Has Been Applied at the Regional and Local Scales in California

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RAND Study* Developed Methodology to Identify Water Management Strategies Robust to the Uncertain Future

How should the Inland Empire Utilities Agency augment its Urban Water Management Plan to prepare for climate change?

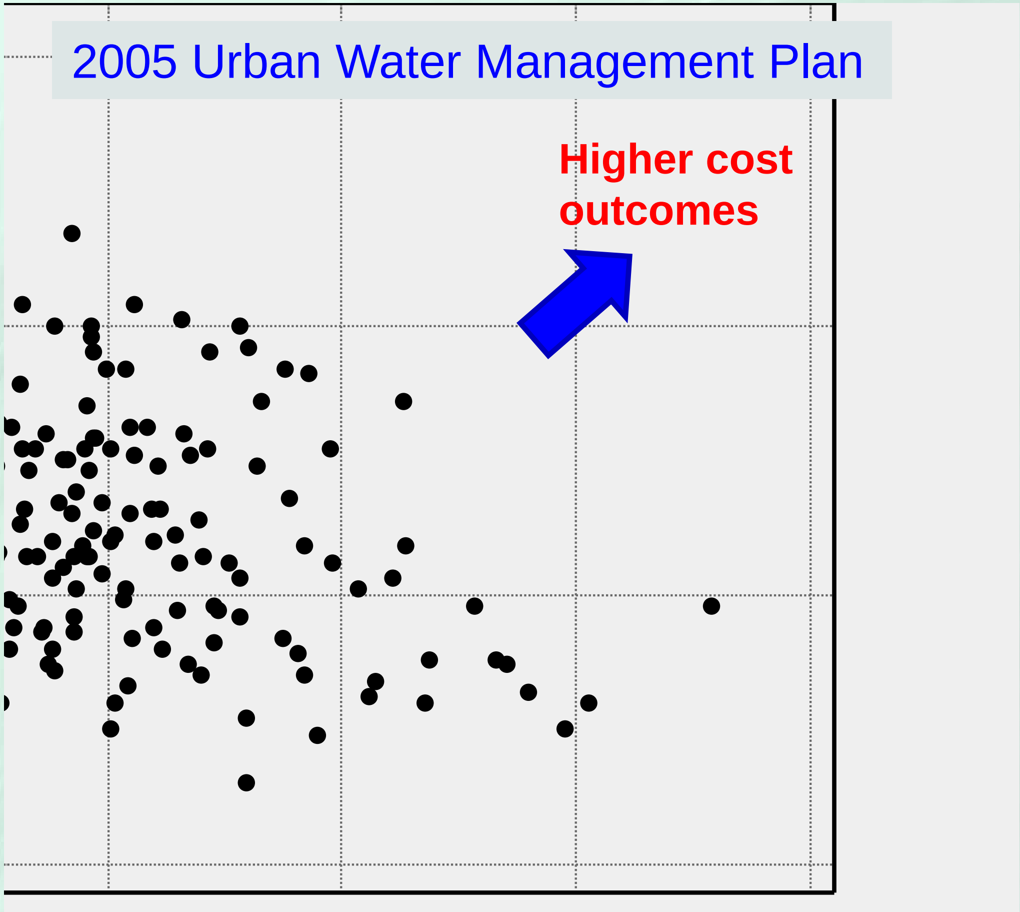
1. **Evaluated UWMP under many future scenarios**
2. **Identified key vulnerabilities of the UWMP**
3. **Analyzed additional strategies that could mitigate these vulnerabilities**
4. **Explored key tradeoffs among strategies**

* Funding provided by the National Science Foundation

Research Team Worked Collaboratively with Water Managers and Stakeholders

- Held four workshops
  - o Discussed future challenges, potential adaptations, and performance metrics
  - o Presented and evaluated different approaches for incorporating uncertainty
    - – Simple scenarios
    - – Probabilistic assessment
    - – Robust decision methods
- Developed WEAP model of IEUA system
- Documented analysis and workshops in two reports

1) Performance of Current Plan Would Vary Widely Under Plausible Scenarios



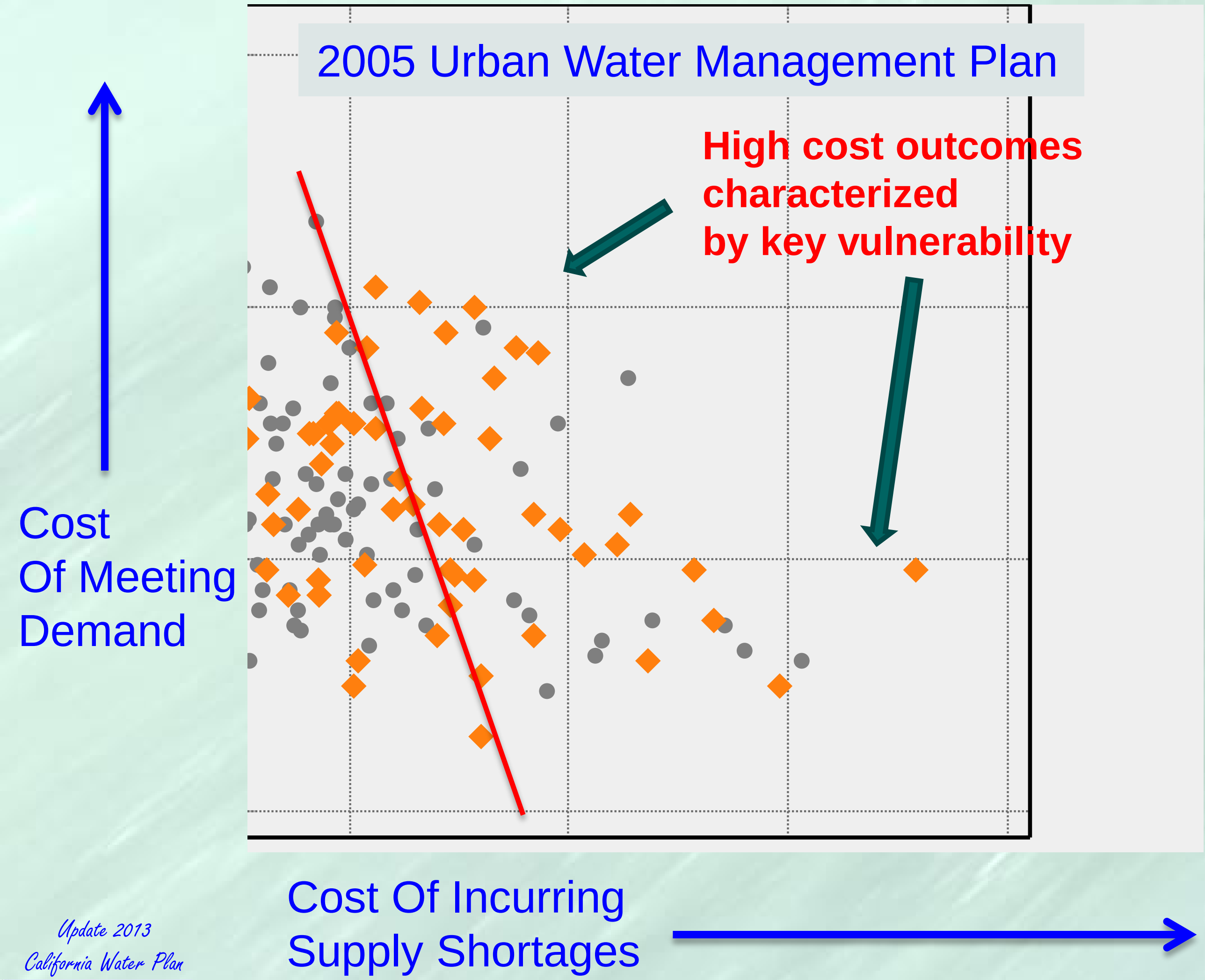
Cost Of Meeting Demand

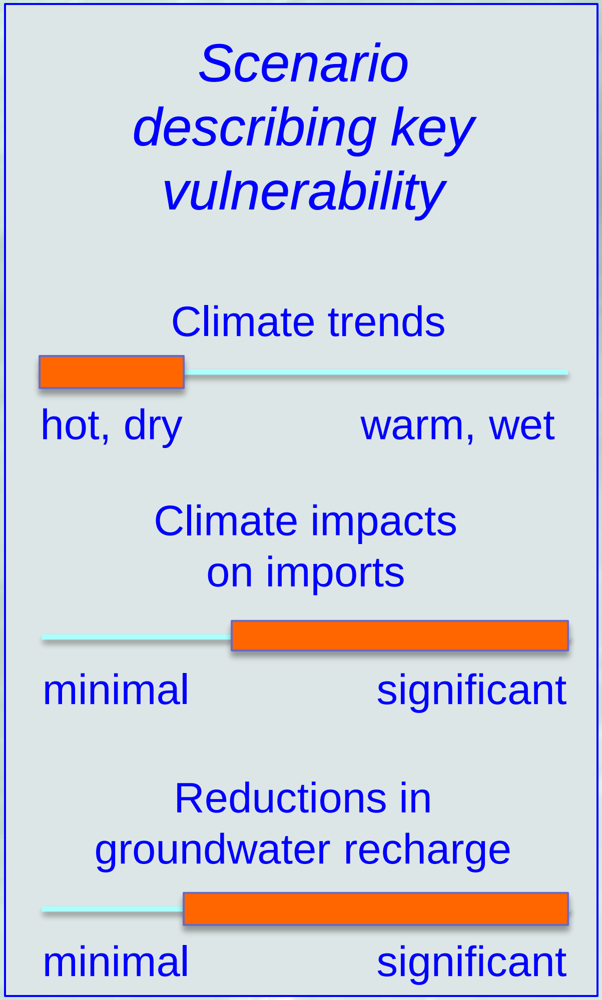
Cost Of Incurring Supply Shortages

200 scenarios reflect uncertainties

- Climate change
- Demographics
- Import availability
- Groundwater yield
- Costs
- Others

2) Plan Was Vulnerable to Warm and Dry Climates; Declines in Groundwater Recharge and Import Availability





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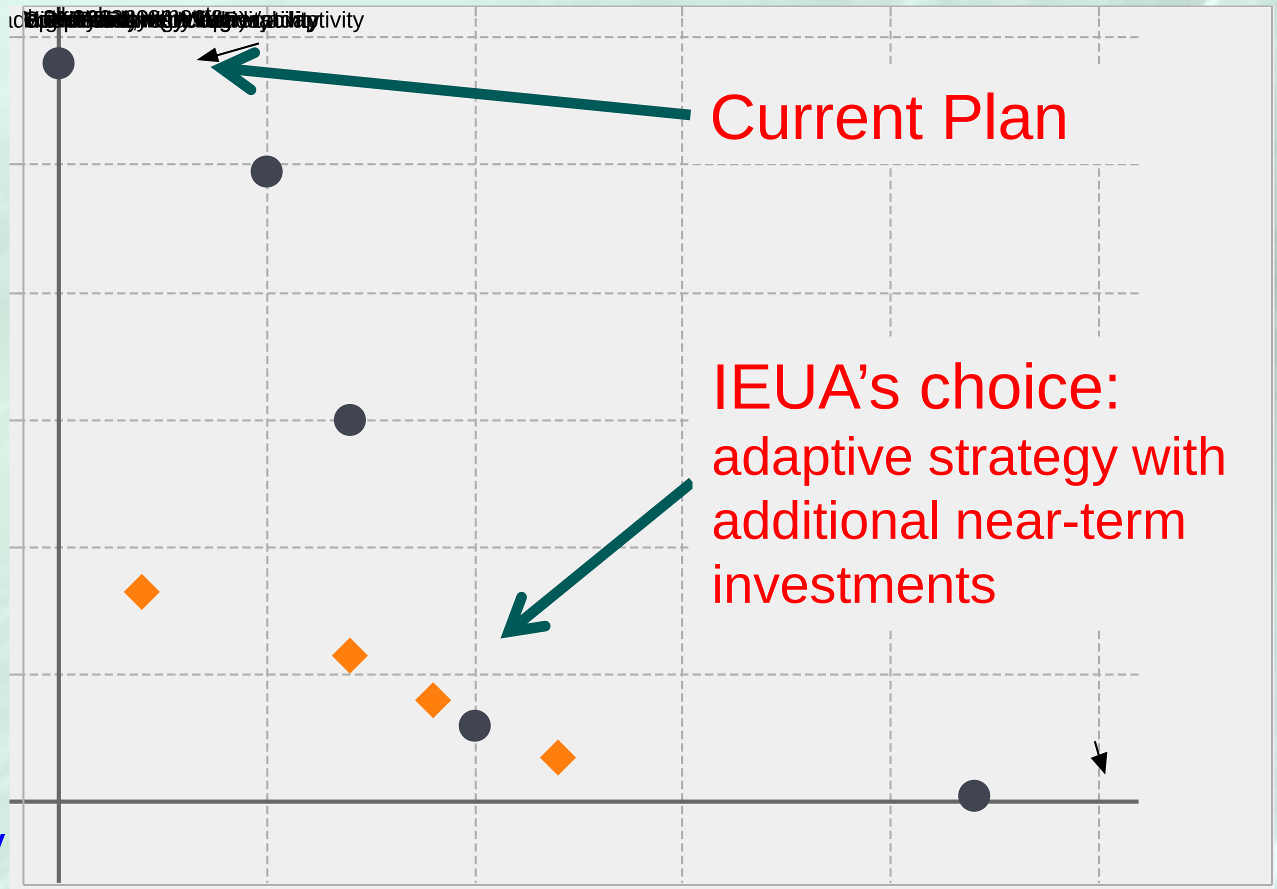
3) Evaluated Additional Resource Management Strategies To Mitigate Key Vulnerability

- Increased efficiency
- Accelerated groundwater banking
- Accelerated water recycling
- Stormwater capture and banking

- "Adaptive strategies" that increase investment only when needed

4) Additional Strategies Would Reduce High-Cost Outcomes at Additional Effort

Number of Scenarios in Which Performance Of Plan is Unsatisfactory



Additional Effort Required to Implement Plan

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Planning Approach Has Been Applied at the Regional and Local Scales in California

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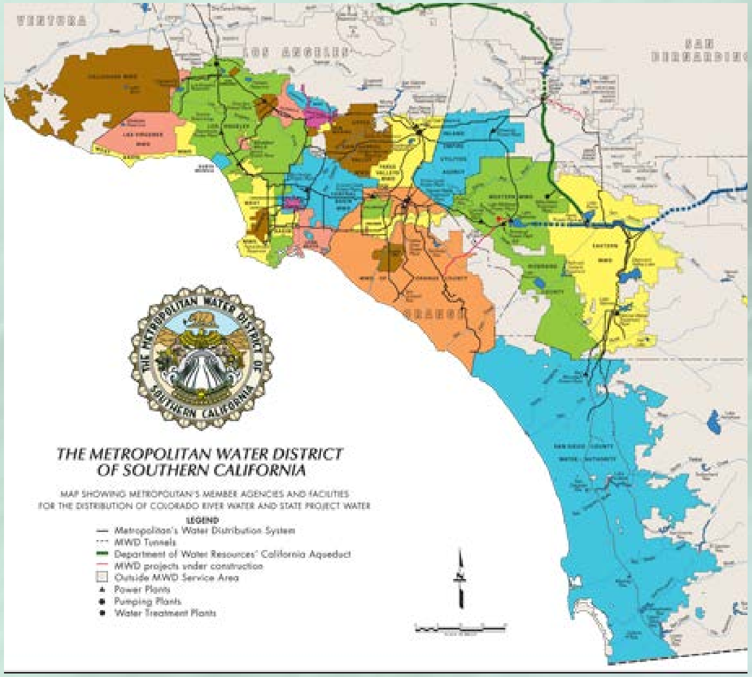
- *Metropolitan Water District of Southern California*: Vulnerability Assessment of its 2010 Integrated Resources Plan (MWD: 2011-present)

Vulnerability Assessment of Metropolitan's 2010 Integrated Resource Plan

- The Metropolitan Water District of Southern California:
  - Serves 26 member agencies.
  - Has a mission that calls for it to "*provide its service area with adequate and reliable supplies of high-quality water to meet present and future needs in an environmentally and economically responsible way*"



- Metropolitan's 2010 Integrated Resources Plan
  - Describes a 25 year investment and policy plan
  - Calls explicitly for 10% buffer and adaptive management to address uncertainty

Analysis* Evaluated Robustness of 2010 Integrated Resources Plan to Range of Future Scenarios

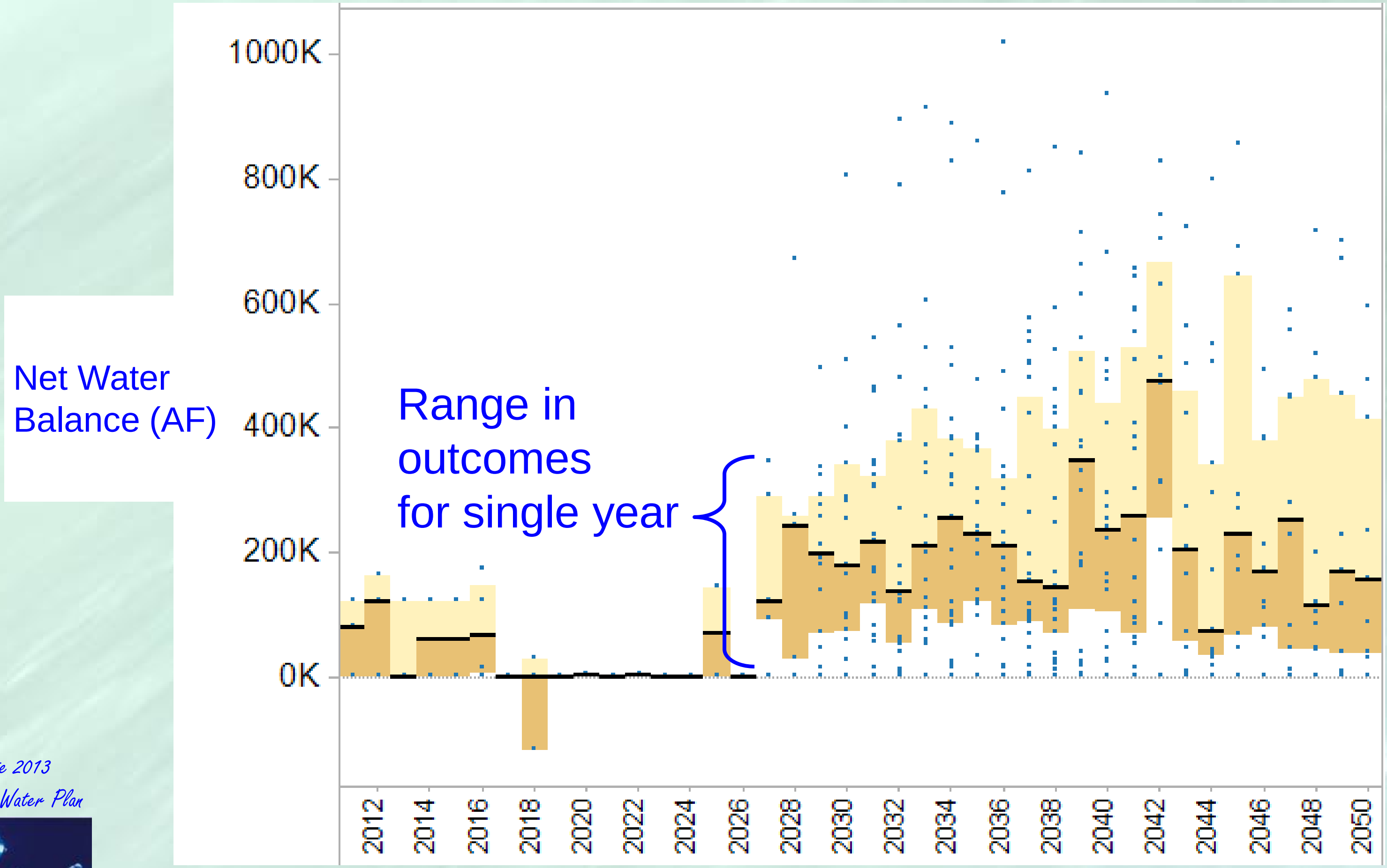
Scenario factors (X)	Management (L)
• Temperature and precipitation • Regional patterns of development, demand for water • Yields from local resources • Timeliness of IRP project implementation	• 2010 Integrated Resources Plan Update
Relationships (R)	**Performance metrics (M)**
• IRPsim • Low-resolution model Colorado River supply • WEAP model of State Water Project	• Net water balance • Storage • *Cost* • *Environmental impact*

These uncertainties and measures emerged from discussions with Metropolitan's stakeholders and staff

* Implemented by RAND / Metropolitan research team

Simulation Models Evaluated Integrated Resource Plan For Individual Scenarios

One case: Single population growth and climate scenario



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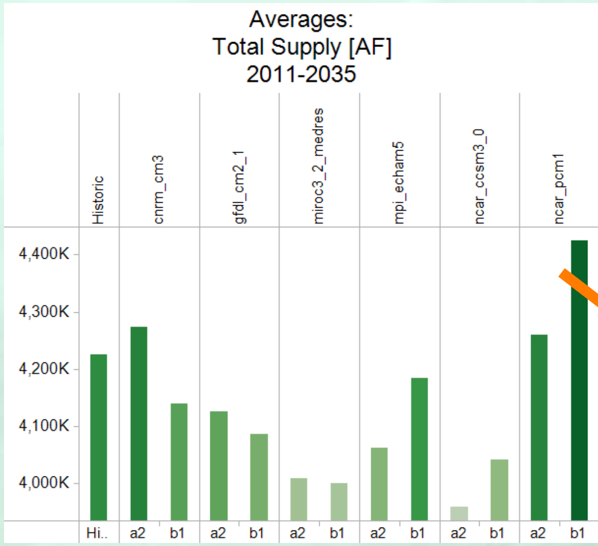
Analysis Considered Many Scenario Factors

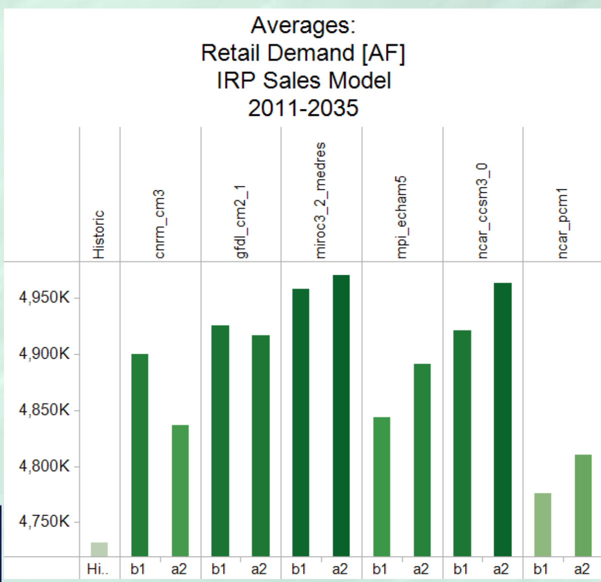
Climate	6 GCMs x 2 emissions scenarios
Demand	4 cases: 1) Balanced growth, 2) IRP sales model, 3) peri-urban growth, 4) high growth
Delta	3 cases: 1) Full Delta supply, 2) 90% Delta supply, 3) No improvement in Delta supply
Yield	26 cases for project yields • Groundwater yields (80% - 120%) • Recycling yield (80% - 120%) • Conservation savings per expenditure (80%-120%)
Implementation	16 cases for project implementation delays • Desalination delays (0 to 10 years) • Recycling (0 to 10 years) • Conservation (10 to 20 years) • State Water Project (0 to 30 years) • Colorado River allocations (0 to 30 years)

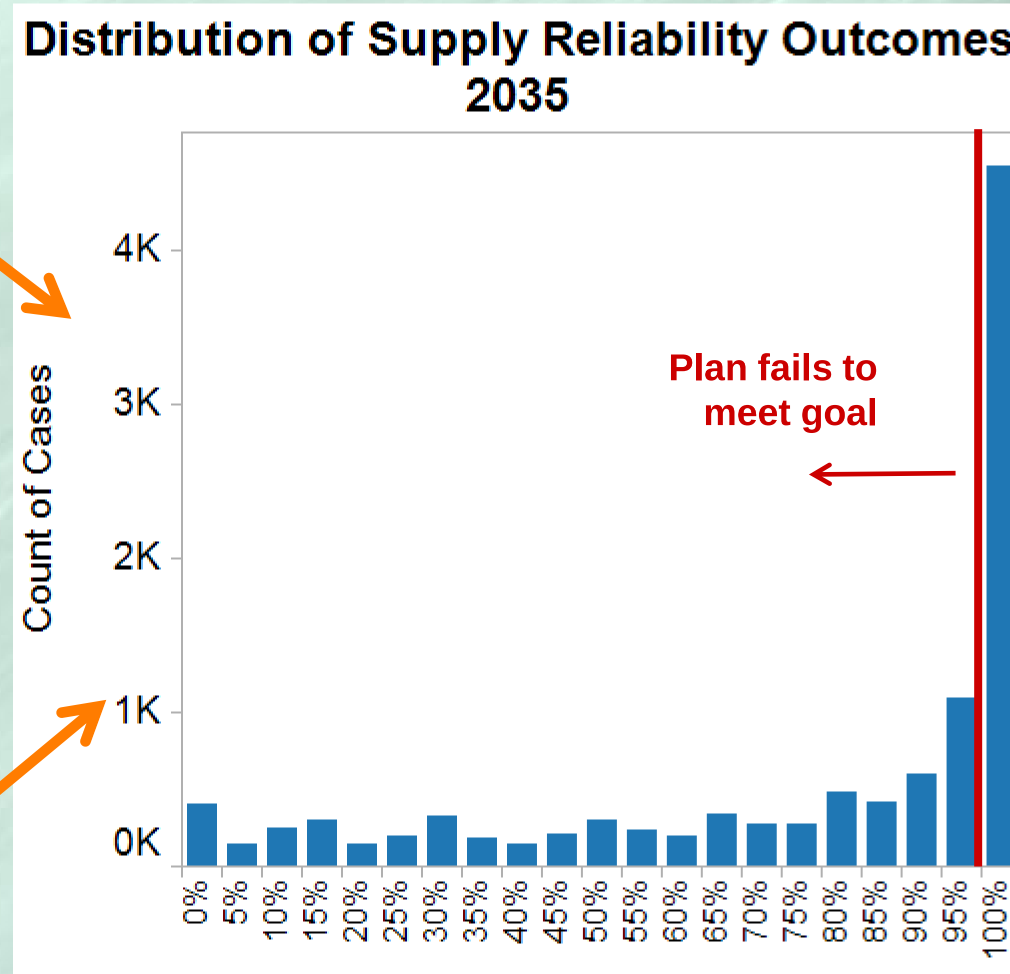
Uncertainties (X)	**Policy Levers (L)**
Relationships (R)	Measures (M)

Consider performance of Metropolitan's IRP in 10,368 cases

IRP Shows Significant Variation in Performance Across The Scenarios







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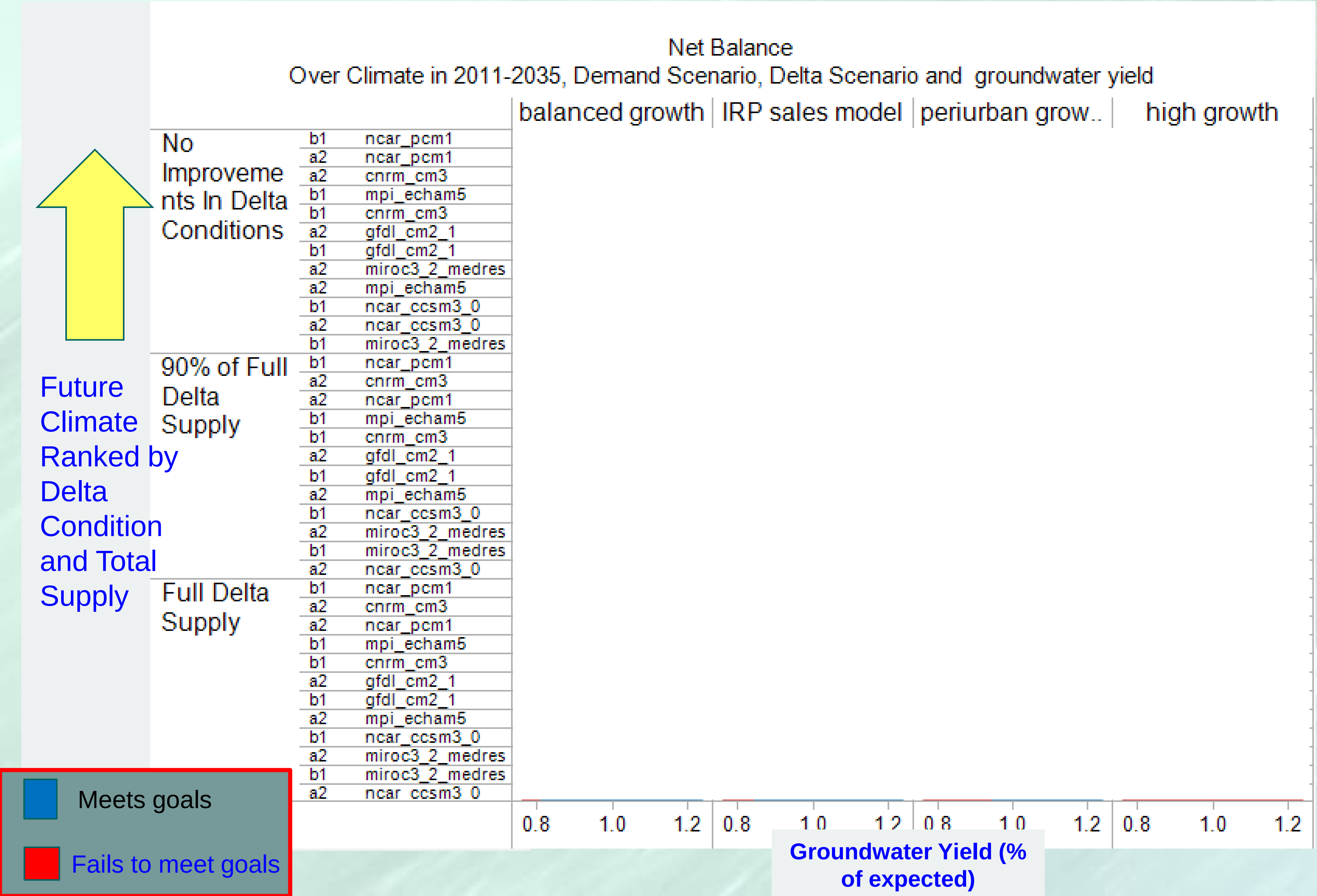
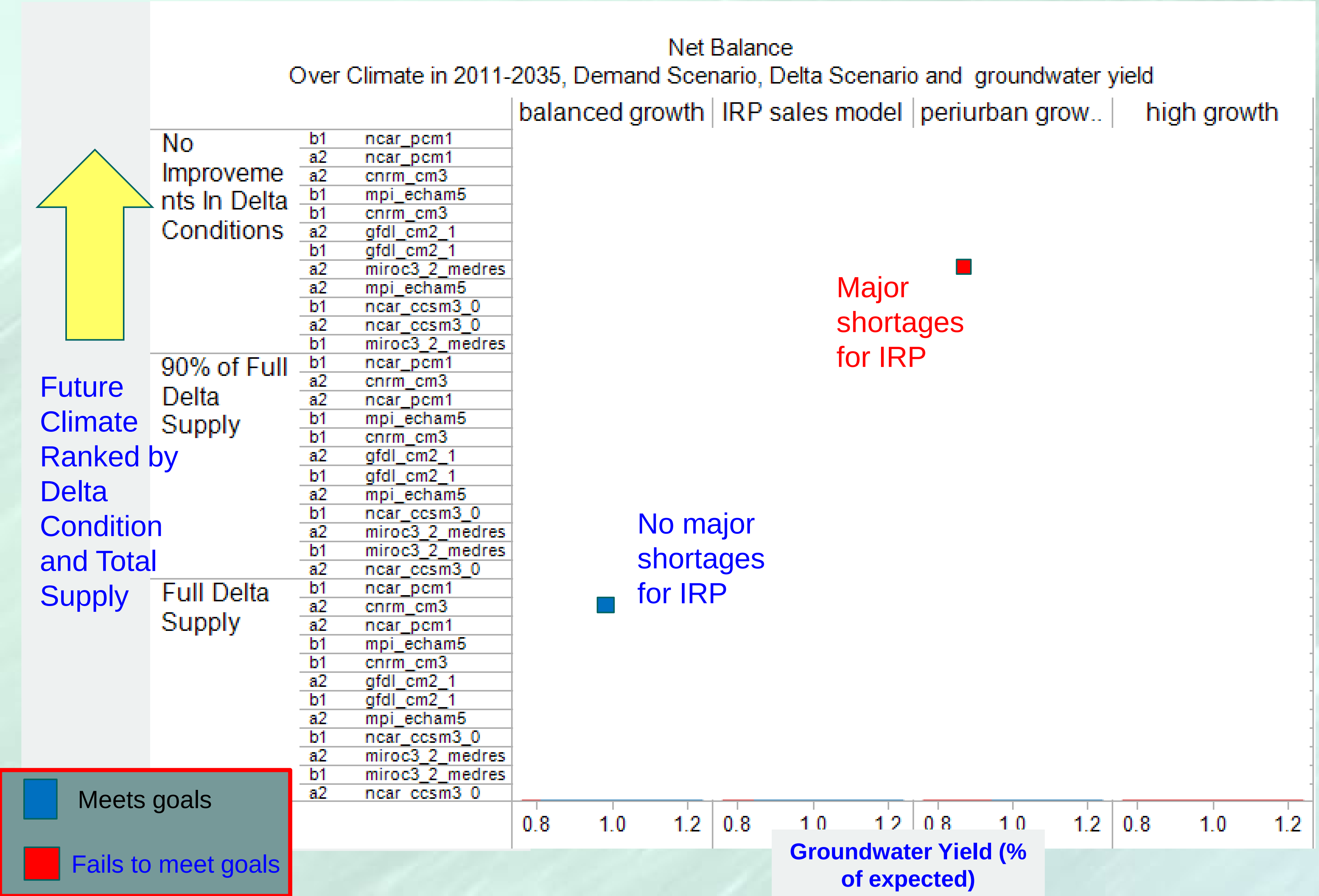
Visualizations Show Key Drivers of Futures Where IRP May Fail to Meet Goals

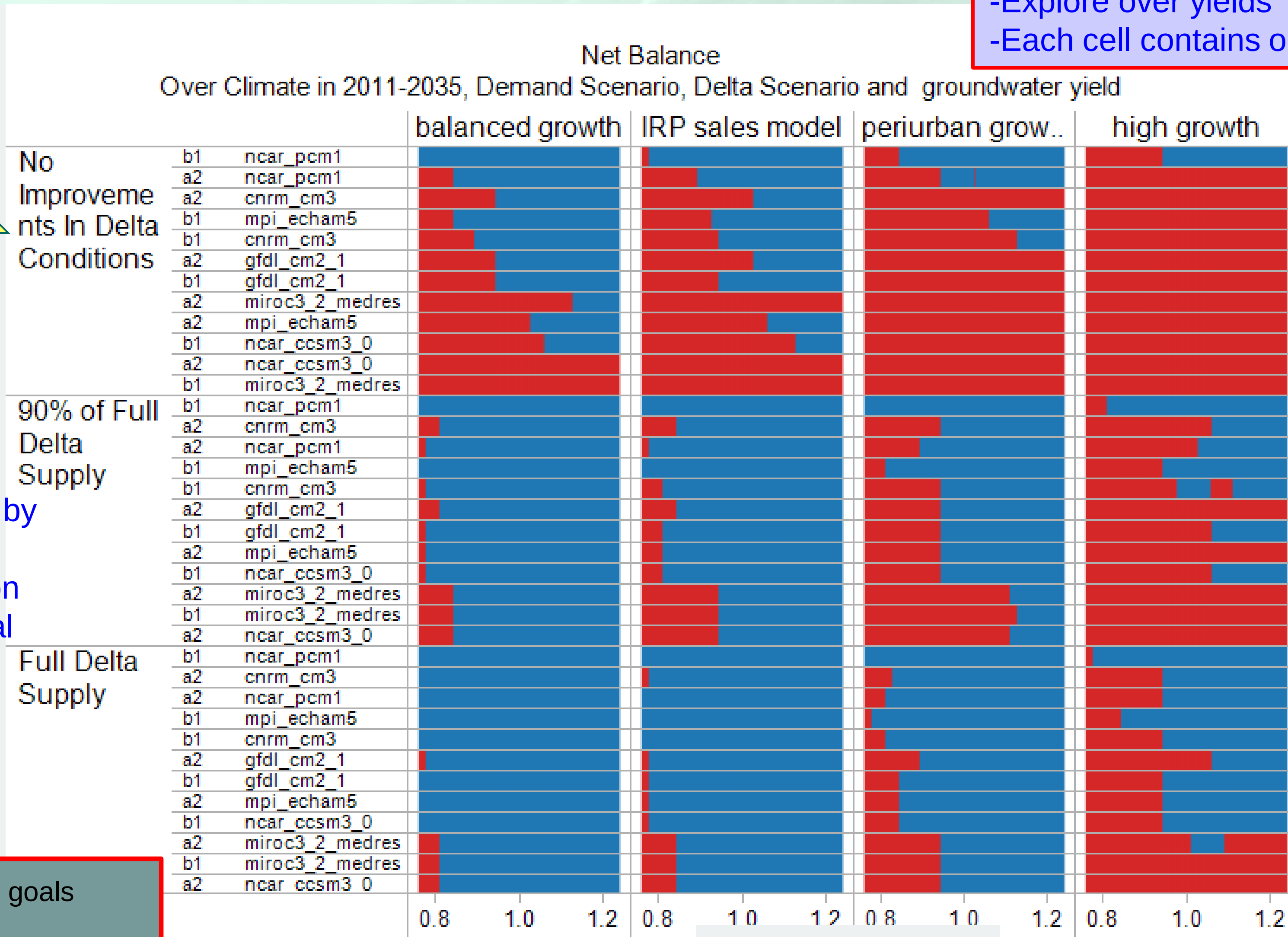


Visualizations Show Key Drivers of Futures Where IRP May Fail to Meet Goals



Visualizations Show Key Drivers of Futures Where IRP May Fail to Meet Goals

-All delays at zero
-Explore over yields
-Each cell contains one case



Future Climate Ranked by Delta Condition and Total Supply

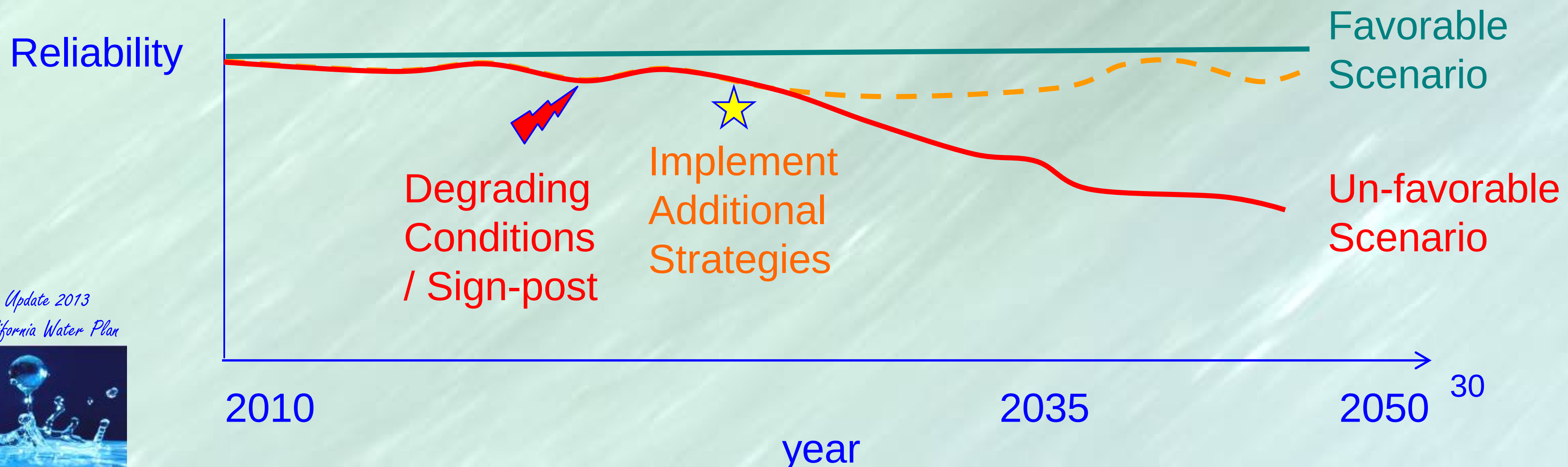
Meets goals

Fails to meet goals

Groundwater Yield (% of expected)

On-Going Analysis Identifying Signposts That Trigger Additional Implementation

- What specific conditions would the baseline IRP under perform?
- What should Metropolitan monitor to trigger additional investment needs?
  - o Climate, demographic trends ; other supply conditions



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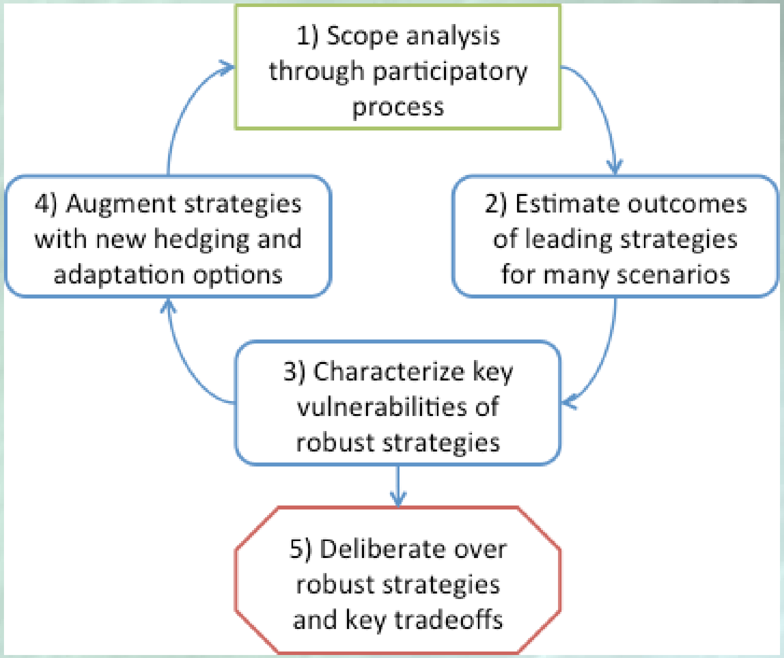
Questions on Case Studies?

CWP 2013 Proof-of-Concept Analysis Demonstrates Planning Approach

- Evaluates current management and other response packages against climate and land use scenarios using WEAP model
- Identifies key vulnerabilities for current and expected management
- Illustrates how additional response packages can reduce vulnerabilities
- Defines key cost and risk tradeoffs



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POC Study Scope Developed in Conjunction with CWP Staff and Stakeholders

- Used existing data and tools developed for the CWP Update 2009
- Focused on the Central Valley
    - Sacramento River and San Joaquin River
- Consider conditions through 2050

Summary of Proof-of-Concept Scope

X Uncertain Factors and Scenarios

Population
Household factors
Employment factors
Environmental flow requirements

→ Land use / demographic scenarios (3)

Climatic conditions

→ Temperature / precipitation scenarios (12)

L Management Strategies and Response Packages

Agricultural water use efficiency
Urban water use efficiency
Conjunctive management & groundwater storage
Recycled municipal water

R Water Management Model

WEAP PA model for Central Valley

M Performance Metrics

Supply Reliability (Urban & Agriculture)
Exports to Southern California
Environmental flow requirements
Costs

Proof-of-Concept Considered Four Key Performance Measures

- **Urban water supply reliability**
  - o % of years in which at least 99% of demand is met

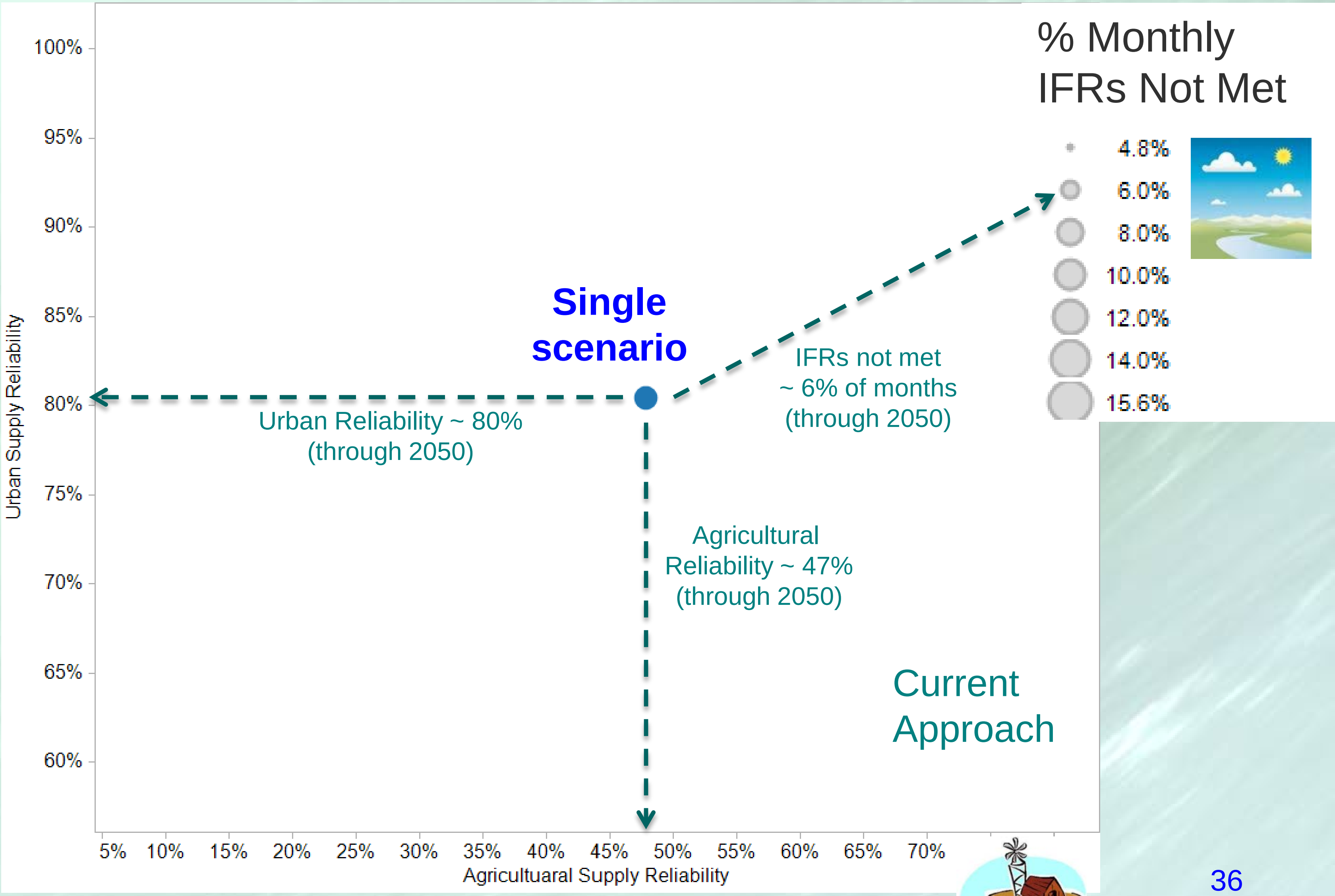
- **Agricultural water supply reliability**
  - o % of years in which at least 95% of agricultural demand is met

- **Environmental performance**
  - o % of months in which all In-stream Flow Requirements (IFRs) are met

- **Cost of implementing strategies**
  - o Notional cost estimates

Performance measures calculated at the Planning Area and Hydrologic Region scales

Performance of "Current Approach" Under a Single Scenario



Urban water supply reliability (%)

Agricultural water supply reliability (%)

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Proof-of-Concept Evaluated Three Demographic and Land Use Scenarios ...

Factors of Uncertainty	Current Trends	Slow & Strategic Growth	Expansive Growth
	Recent trends are assumed to continue into the future. Regulations are not coordinated or comprehensive, creating uncertainty for planners and managers. The state continues to face lawsuits, from flood damages to water quality and endangered species protections.	Private, public, and governmental institutions form alliances to provide for efficient planning and development that is less resources intensive than current conditions. State government implements comprehensive and coordinated regulatory programs to improve water quality, protect fish and wildlife, and protect communities from flooding.	Future conditions are more resource intensive than existing conditions. Protection of water quality and endangered species is driven mostly by lawsuits. State government has responded on a case-by-case basis, creating a patchwork of regulations and uncertainty for planners and water managers.
Population	59.5 million* (22.8 million increase)	44.2 million (7.5 million increase)	69.8 million (33.1 million increase)
Land Use	Continued development	Compact development	Sprawling development
Irrigated Crop Area	8.6 million acres (0.7 mil. acre decrease)	9.0 million acres (0.2 mil. acre decrease)	8.2 million acres (1.0 mil. acre decrease)
Environmental Water	1.0 additional MAF	1.5 additional MAF	0.6 additional MAF
Background Water Conservation	10% more efficient	15% more efficient	5% more efficient

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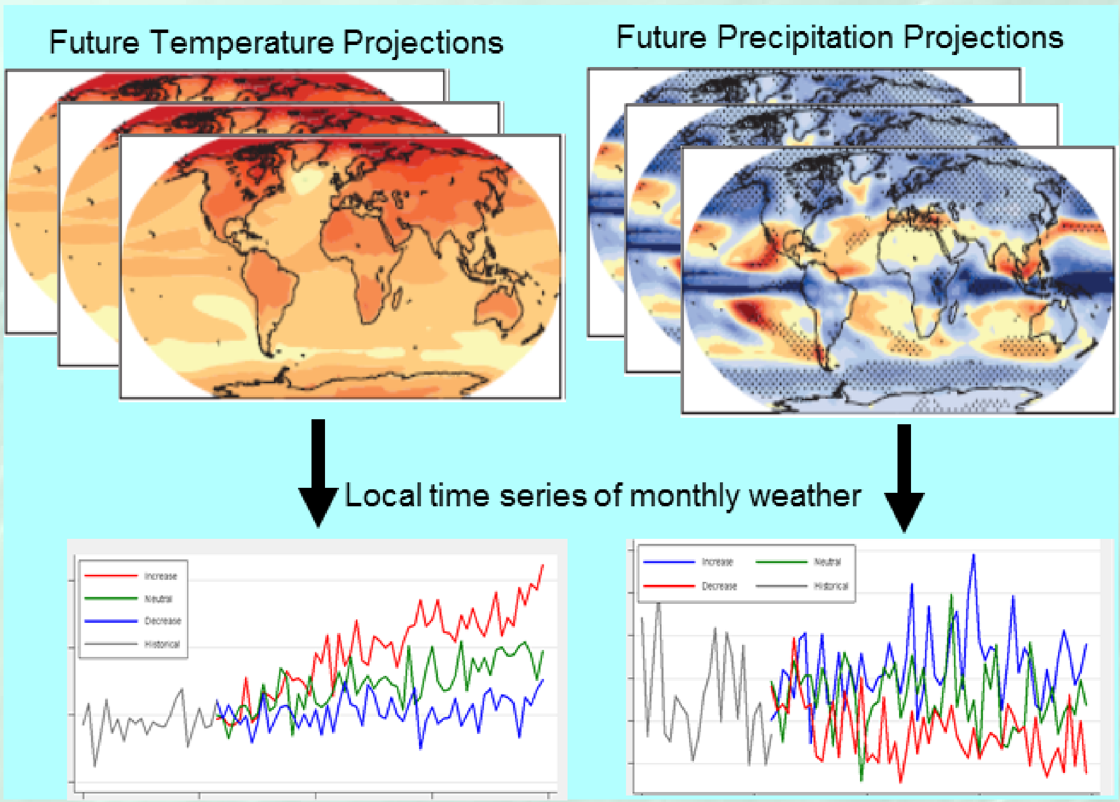
… and 12 Climate Scenarios

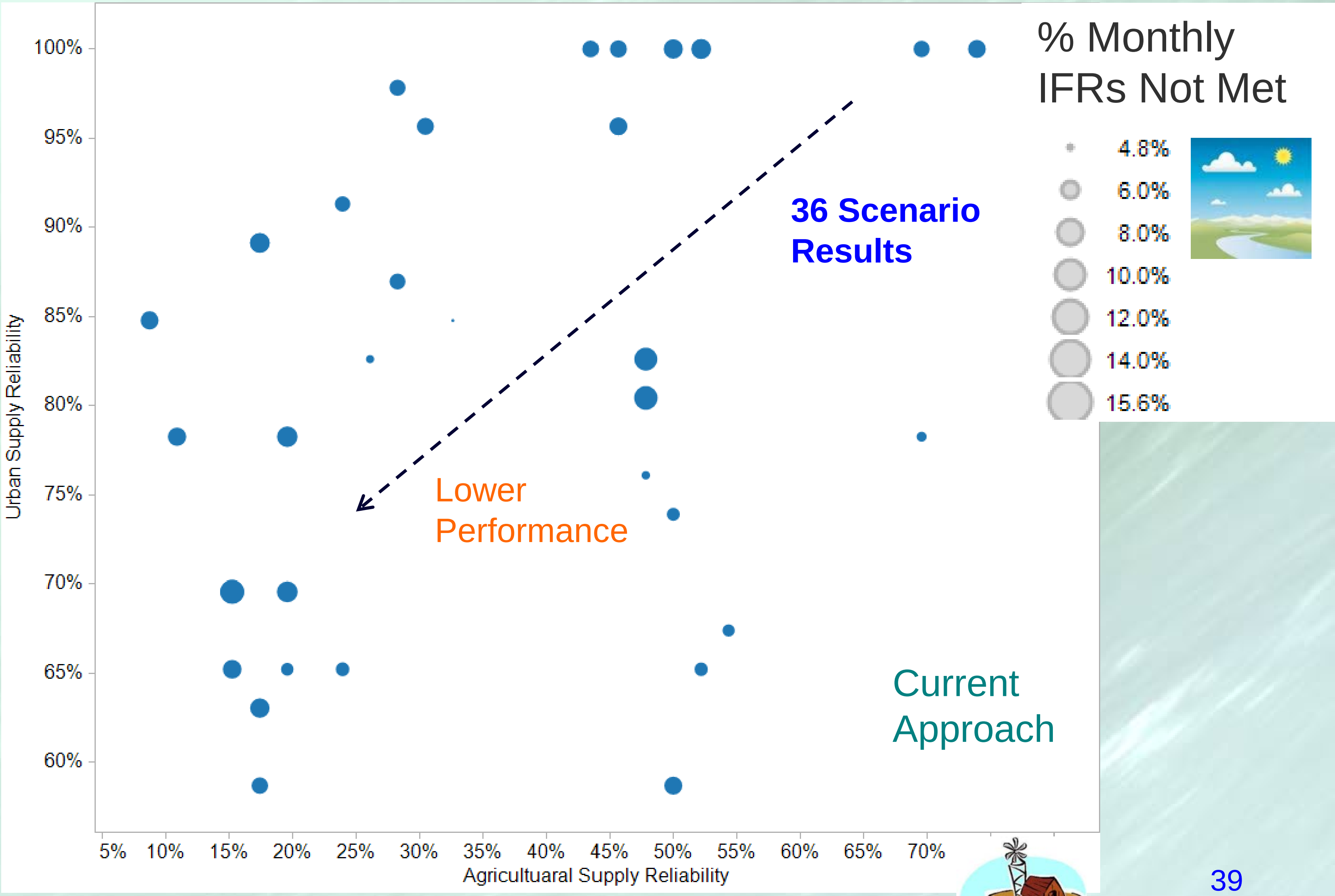
Downscaled AOGCM climate sequences



- 6 global climate models
- Two global carbon emissions scenarios

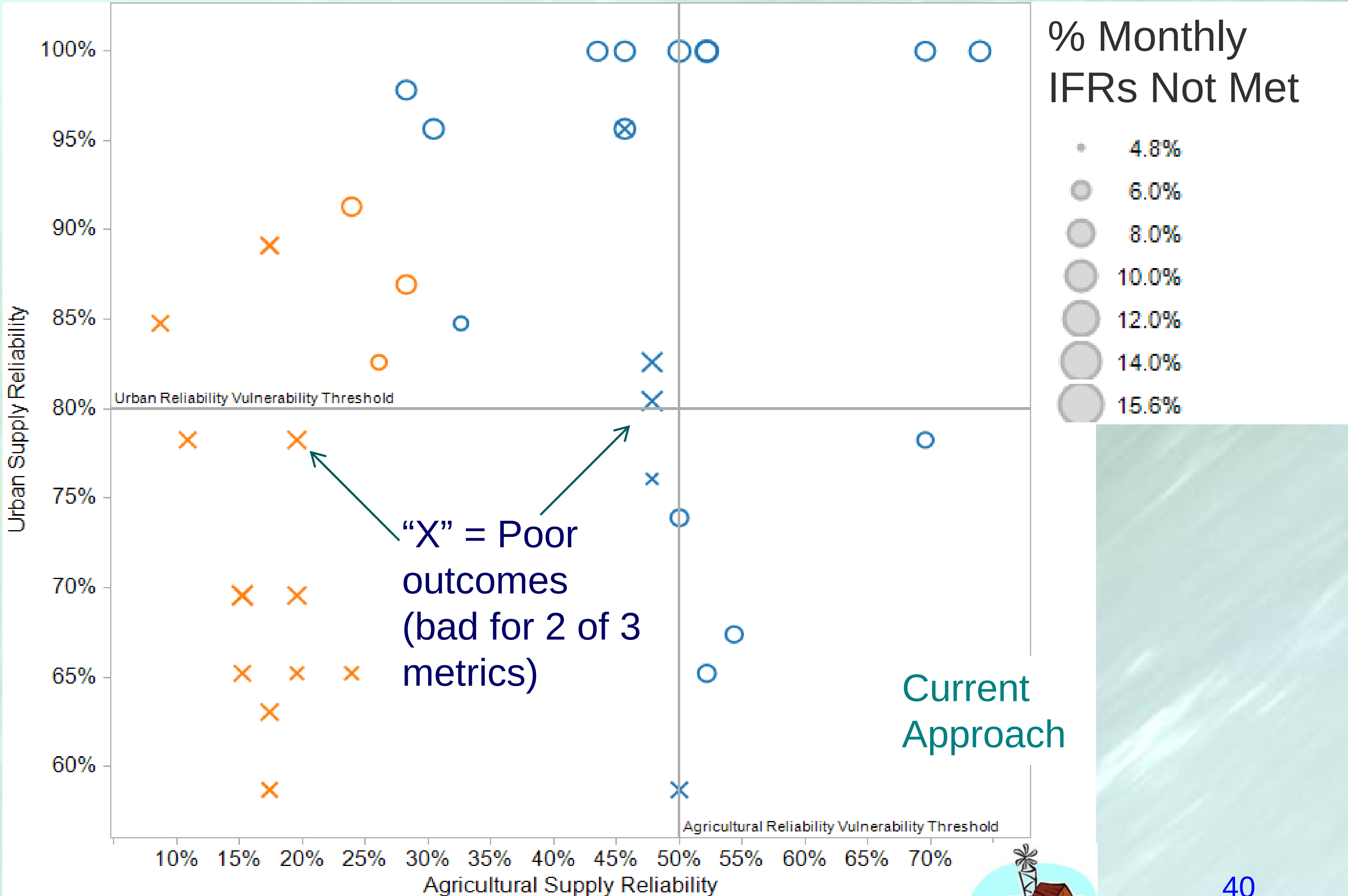
Performance of “Current Approach” Under 36 Scenarios

Urban water supply reliability (%)



Agricultural water supply reliability (%)

Analysis Identified and Characterized Poor Outcomes



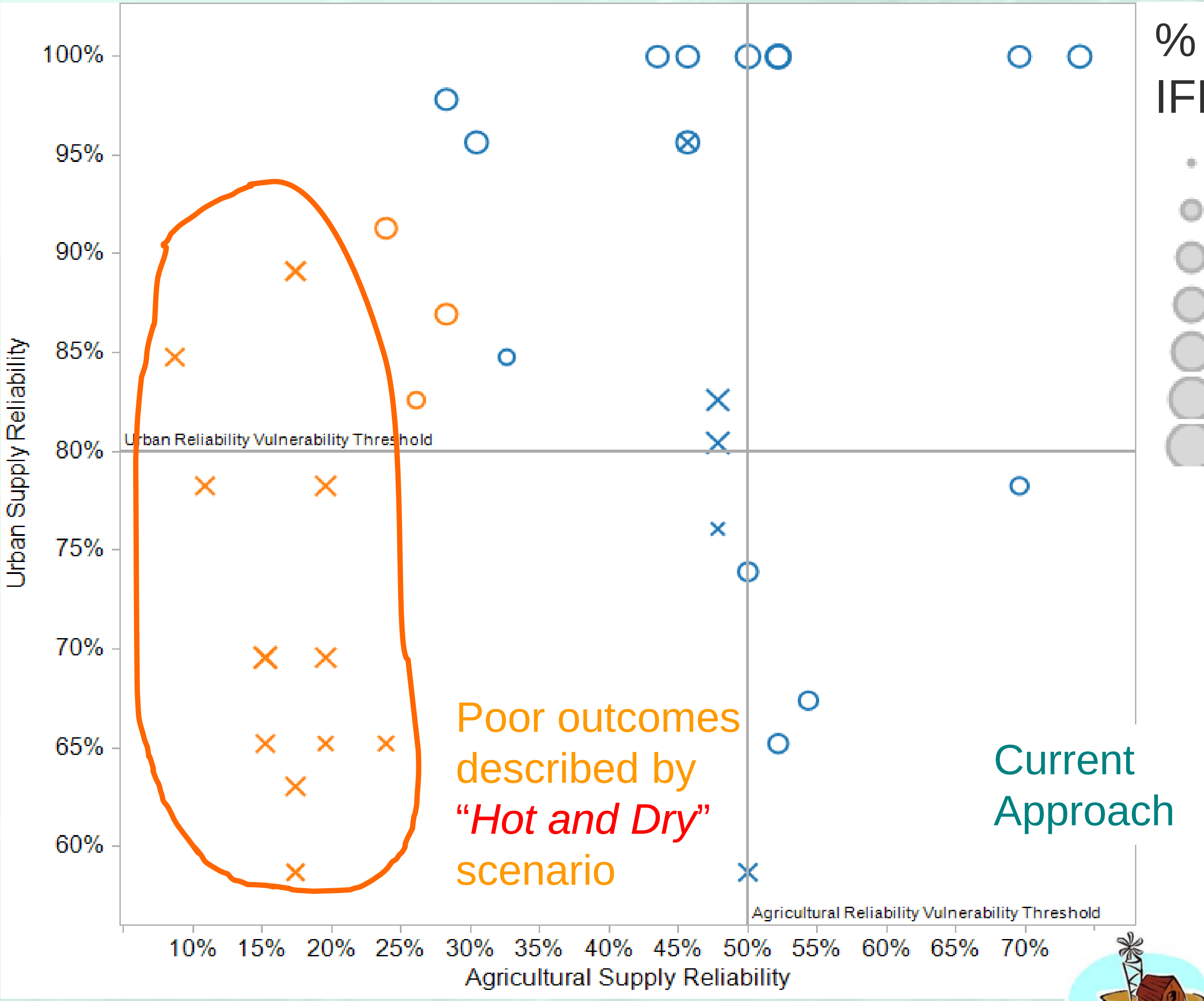
Urban water supply reliability (%)

Agricultural water supply reliability (%)

Update 2013 California Water Plan

Climate Trends Define "*Hot and Dry*" Vulnerable Scenario

Urban water supply reliability (%)



Agricultural water supply reliability (%)

Considered Water Management Strategies to Reduce This Vulnerability

- Urban water use efficiency
- Agricultural water use efficiency
- Groundwater recharge
- Recycled water use

Grouped Strategies into Response Packages for Analysis

Strategies							
Urban Water Use Efficiency							
Agricultural Water Use Efficiency							
Groundwater Recharge							
Recycled Water Use							

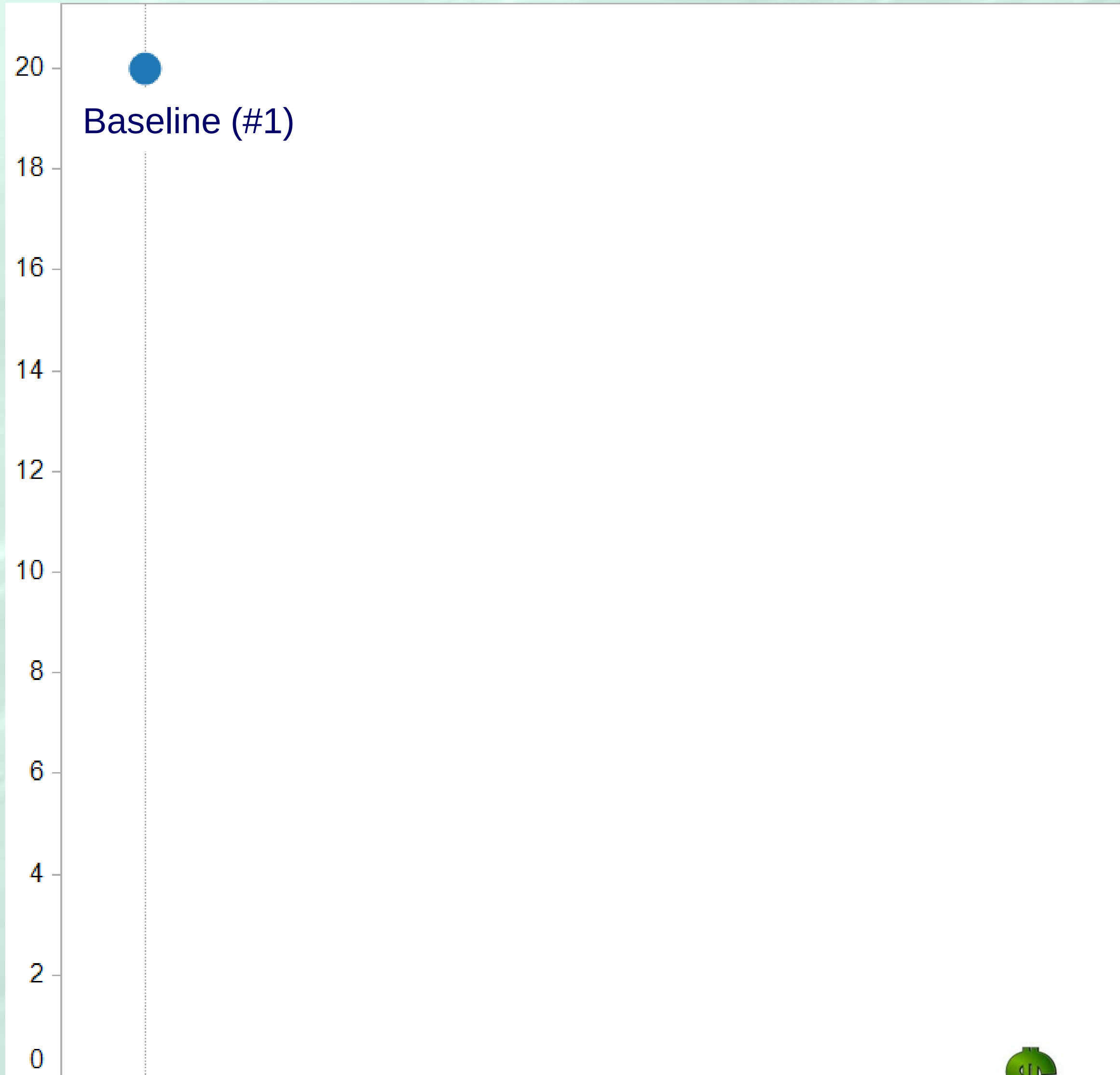
Grouped Strategies into Response Packages for Analysis

Response Packages

Strategies	Baseline (#1)	#2	#3	#4	#5	#6	#7
Urban Water Use Efficiency	O (current)	+	+	++	++	++	+++
Agricultural Water Use Efficiency	O	O	O	+	+	+	+++
Groundwater Recharge	O	O	+	O	+	+++	+++
Recycled Water Use	O	+	++	+	++	+++	+++

Implementing Additional Strategies Reduces Vulnerability to Climate Uncertainty

Better performance (decreasing number of scenarios in which performance is unsatisfactory)



Increasing cost / effort

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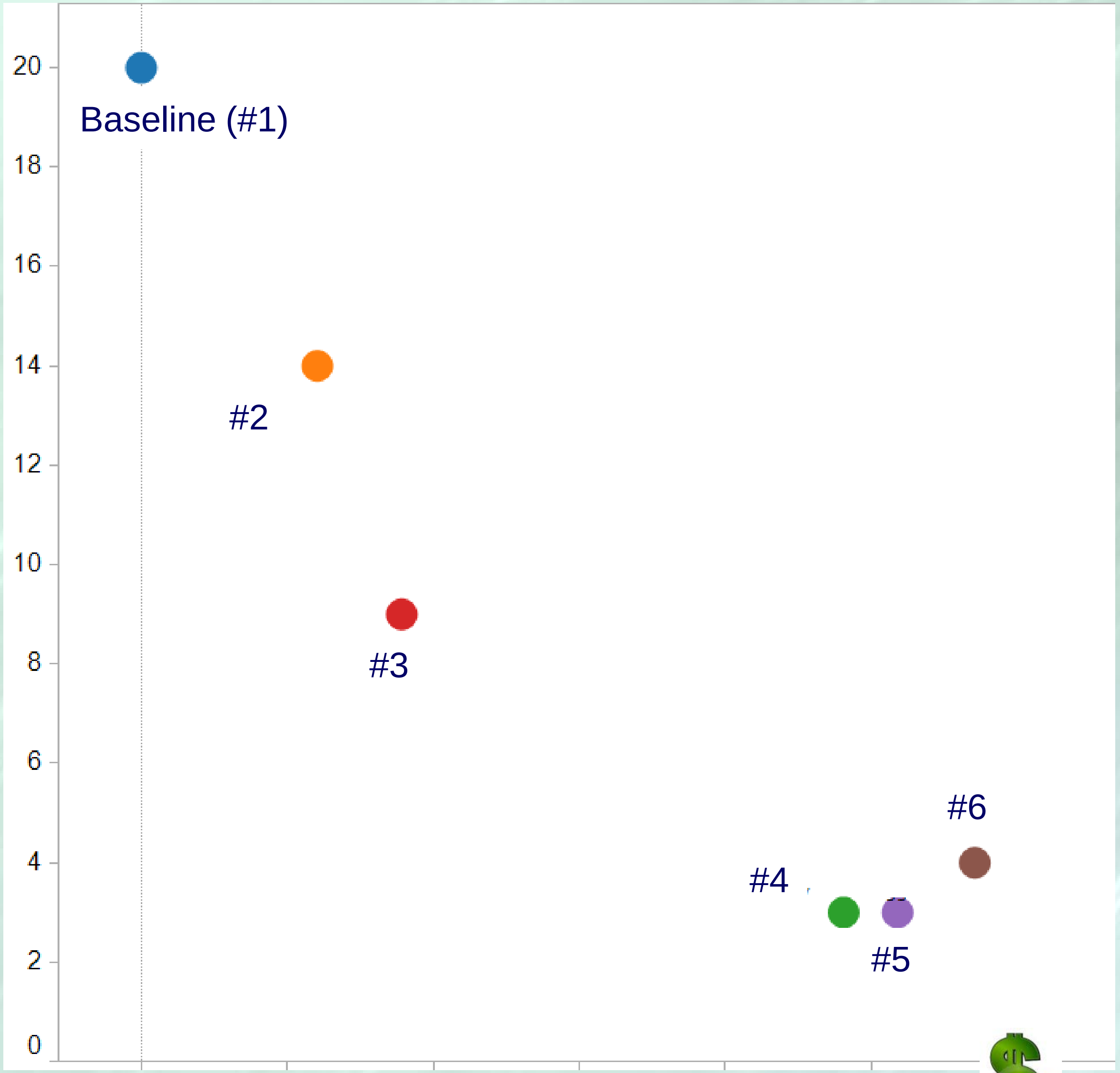
Implementing Additional Strategies Reduces Vulnerability to Climate Uncertainty

Better performance (decreasing number of scenarios in which performance is unsatisfactory)



Increasing cost / effort

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Workshop Discussion Topics

- Future land use changes
- Resource management strategies
- Evaluating performance of resource management strategies

Workshop Discussion Topics

- Future land use changes
- Resource management strategies
- Evaluating performance of resource management strategies

Future Land Use Changes

- What significant changes in land use development should we consider for Update 2013?
  - For example, how will residential densities change in the future?
- In addition to population growth, are there other significant factors affecting conversion of agricultural land to other uses?
  - For example, habitat restoration or land retirement

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Workshop Discussion Topics

- Future land use changes
- Resource management strategies
- Evaluating performance of resource management strategies

Update 2013 Will Evaluate and Compare Resource Management Strategies

- Wide range of resource management strategies available
- Many strategies can be implemented in different locations, at different times, and to different extents
- Interactions among strategies can be important
- Response packages describe groups of strategies for comparison

Resource Management Strategies (Update 2009)

Reduce Water Demand
- Agricultural Water Use Efficiency
- Urban Water Use Efficiency

Improve Operational Efficiency & Transfers
- Conveyance – Delta
- Conveyance – Regional / Local
- System Reoperation
- Water Transfers

Increase Water Supply
- Conjunctive Management & Groundwater Storage
- Desalination –Brackish & Seawater
- Precipitation Enhancement
- Recycled Municipal Water
- Surface Storage – CALFED
- Surface Storage – Regional / Local

Improve Flood Management
- Flood Risk Management

Improve Water Quality
- Drinking Water Treatment & Distribution
- Groundwater / Aquifer Remediation
- Matching Quality to Use
- Pollution Prevention
- Salt & Salinity Management
- Urban Runoff Management

Practice Resource Stewardship
- Agricultural Lands Stewardship
- Economic Incentives (Loans, Grants & Water Pricing)
- Ecosystem Restoration
- Forest Management
- Land Use Planning & Management
- Recharge Areas Protection
- Water-Dependent Recreation
- Watershed Management

Other-- Crop idling, dew vaporization, fog collection, irrigated land retirement, rainfed agriculture, waterbag transport

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Only Some of These Strategies Can Be Modeled With Available Tools

Reduce Water Demand

- Agricultural Water Use Efficiency
- Urban Water Use Efficiency

Improve Operational Efficiency & Transfers

- Conveyance – Delta
- Conveyance – Regional / Local
- System Reoperation
- Water Transfers

Increase Water Supply

- Conjunctive Management & Groundwater Storage
- Desalination –Brackish & Seawater
- Precipitation Enhancement
- Recycled Municipal Water
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Improve Flood Management

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2013 CWP Analysis Can Consider Subset of Strategies

Strategies					
Urban water use efficiency					
Agricultural water use efficiency					
Groundwater conjunctive use					
Wastewater recycling					
Land use planning					
Surface storage					
Reservoir re-operation					
Environmental flow requirements					

Response Packages Group Strategies Thematically

Response Packages

Strategies	Baseline	Locally Planned	Efficiency Focus	Storage Focus	
Urban water use efficiency	o (current)	+			
Agricultural water use efficiency	o	+			
Groundwater conjunctive use	o	o			
Wastewater recycling	o	+			
Land use planning	o	?			
Surface storage	o	o			
Reservoir re-operation	o	o			
Environmental flow requirements	o	o			

Response Packages Group Strategies Thematically

Response Packages

Strategies	Baseline	Locally Planned	Efficiency Focus	Storage Focus	
Urban water use efficiency	o (current)	+	++	+	
Agricultural water use efficiency	o	+	++	+	
Groundwater conjunctive use	o	o	o	++	
Wastewater recycling	o	+	+	+	
Land use planning	o	?	+	o	
Surface storage	o	o	o	++	
Reservoir re-operation	o	o	o	+	
Environmental flow requirements	o	o	+	o	

Resource Management Questions

- What are your top five resource management strategies that could be implemented in your region between now and 2050?
- What themes would describe coherent and relevant response packages for your region?

	Response Packages				
Strategies	**Baseline**	**Locally Planned**	**Efficiency Focus**	**Storage Focus**	
Urban water use efficiency	O (current)	+	++	+	
Agricultural water use efficiency	O	+	++	+	
Groundwater conjunctive use	O	O	O	++	
Wastewater recycling	O	+	+	+	
Land use planning	O	?	+	O	
Surface storage	O	O	O	++	
Reservoir re-operation	O	O	O	+	
Environmental flow requirements	O	O	+	O	
					74

Other Resource Management Questions

- What new environmental water (for instream flows and habitat restoration beyond existing requirements) should we consider in Update 2013?
- What policies could influence future land use and how?

Workshop Discussion Topics

- Future land use changes
- Resource management strategies
- Evaluating performance of resource management strategies

Performance Measures Summarize the Effects of Different Response Packages

Measures should relate to Update 2013 Objectives

- Water Supply & Supply Reliability
- Energy Benefits
- Flood Impact Reduction
- Food Security
- Groundwater Overdraft Reduction
- Environmental Benefits
- Drought Preparedness
- Water Quality
- Operational Flexibility and Efficiency
- Recreational Opportunity

Models and available data may limit which measures can be used

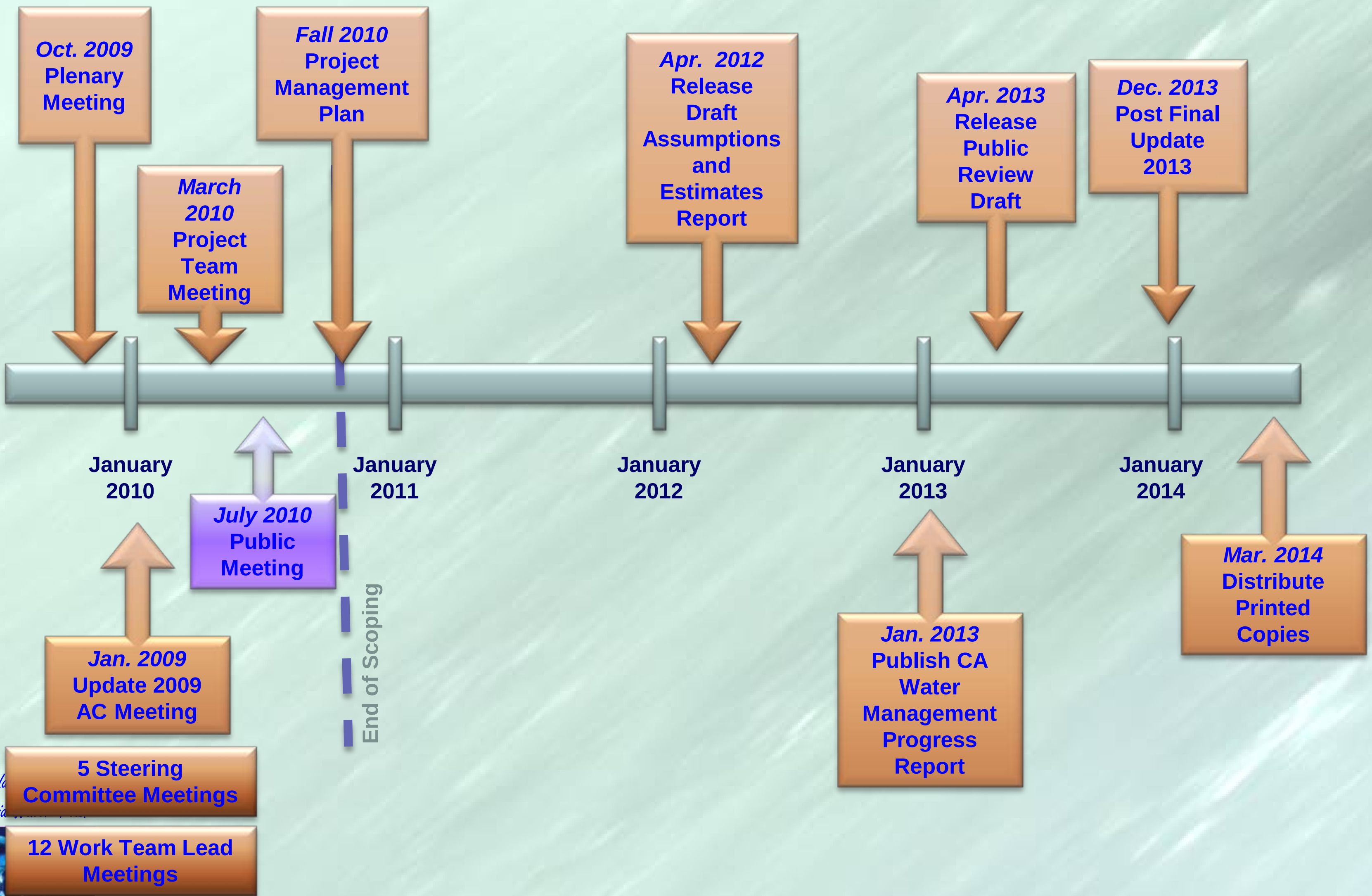
Discussion Questions

- Which performance measures are essential to make investment decision about different resource management strategies?
- Which temporal scales (daily, monthly, annual, etc.) and planning horizon (2020, 2050, 2100) are most useful to your decisions about investing in resource management strategies?
- Which spatial scales (water district, IRWM region, hydrologic region, tribal, statewide) are most useful to your decisions about investing in resource management strategies?

Next Steps

- Incorporate workshop input into the Update 2013 assumptions and analytical approach to evaluate future water management conditions in California.
- Identify IRWM Regional Water Management Groups (find volunteers) in Sacramento River, San Joaquin River, and Tulare Lake Hydrologic Regions to identify regional resource management strategies (response packages)
- Conduct WEAP simulations using an iterative process with Regional Water Management Groups.
- Present interim results to other Update 2013 advisory groups (State Agency Steering Committee, Public Advisory Committee, Statewide Water Analysis Network, Tribal Advisory Committee)

Water Plan Update 2013
Timeline and Major Deliverables



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SWAN - http://www.waterplan.water.ca.gov/swan